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Modeling the impact of exchange rates using a multicurrency framework

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ABSTRACT

Multiple currencies are the reality in a global economy but this reality is difficult to be replicated in a model. The GTAP model avoids this issue by converting values for each country into US dollars. This approach simplifies the model greatly; however, it ignores the important role of exchange rates in international trade and in world economic development. By adopting a multicurrency framework and adding bilateral exchange rates for any two regions, this paper provides a revised version of GTAP model, which can model the impact of exchange rate policy with ease. The impact of an appreciation of the Chinese Yuan is simulated in the paper to illustrate the way to model exchange rates. The simulation results are consistent with macroeconomic and trade theories and are well-explained by the economic structure of China and its trading partners.

1. Introduction

Because of the numerous conversions in international trade and global aggregations, multiple currencies are a troublesome issue in a multi-country model. The changes in exchange rates during a simulation make the issue even more complex. The GTAP model circumvents this problem by converting values for each country into US dollars. This approach simplifies the model greatly, but it also ignores the role of exchange rates. One may argue that real exchange rates can be calculated based on the bilateral trade volume, but this calculation sheds little light on the predominant influence of exchange rates on international trade, which was demonstrated vividly by the Asian Financial Crisis in 1997, more recently the GFC, and the Chinese government's apparent determination to keep its exchange rates low even under pressure from the US government.

Due to the important role of exchange rates, substantial research has been undertaken to assess the impact of an exchange rate change. For example, a number of studies have considered the effect of a revaluation of the Chinese currency RMB (or Yuan). There are basically two approaches to this topic: econometric modeling and CGE modeling. Examples of the first approach includes, among others, Suresh (2012), Kim and Kim (2012), Shi (2006), Zhang (2006) and Blecker and Razmi (2009). The CGE studies on this topic include Yu et al. (2003), Willenbockel (2006), Tyers and Yang (2000), Yang et al. (2012), and Li and Xu (2011). Since the CGE modeling approach is more relevant to this study, we review it in more detail.

A number of researchers developed single country models for China to gauge the effect of an appreciation of the Chinese Yuan. The benefit of a single country model is that it avoids the complexity of international trade, and the model can be more focused on China's perspectives and can include more details about China. There are two drawbacks in this type of study, however. One is that, since the demand for Chinese exports is determined by the price elasticity of foreign demand in a single country model, the modeling results are not accurate due to the omission of an important variable — the income of foreigners. The second drawback is that there is only one exchange rate in the model because the rest of the world is treated as a single entity. This prohibits modeling complex exchange rate policy. Using this single country approach, Yu et al. (2003) modeled the effects of a real exchange rate devaluation and compared these to the effects of increased rebates of export taxes. The model features two types of firms (ordinary firms and export processing firms), three types of imports (ordinary imports subjected to import tariff and nontariff barriers, duty free imports for producing processed exports, and other duty free imports) and two types of labor (rural labor and urban labor). By comparing the simulation results of a devaluation of the real exchange rate with those of an increase in the export rebate rate, the paper claimed that a 30% increase in the export rebate rate (or equivalently, a 55% increase in the cost to government of the export rebate) have a similar impact to a 5% real exchange rate devaluation in terms of restoring China's export competitiveness. Willenbockel (2006) used a 17-sector model to simulate the structural effects of a real exchange rate revaluation in China. The real exchange rate shock is realized by a decrease in the saving rate which leads to a decrease in China's trade balance by 4% of GDP. The paper concludes that the revaluation of RMB would be associated with fairly moderate intersectoral employment relocation effects.

Most researchers have used a multi-country model for this topic. The advantage of a multi-country model is that it will not only produce more realistic modeling results, but also reveal the impact of exchange rate changes on other countries, predominately China's trading partners. Tyers and Yang (2000) used a modified GTAP model to explore the

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options for China during the Asian Financial Crisis. In this work three scenarios are designed: (1) fiscal expansion, maintaining fixed nominal parity with US$, (2) a nominal wage rise while maintaining fixed nominal parity with the US$, and (3) a nominal devaluation against the US$. The paper concluded that, holding fixed nominal parity with the US$, continued fiscal expansion will cause the home price level and therefore the real exchange rate to rise. This will harm exports and export-oriented manufacturing industries, but will reduce the real wage and foster employment growth. The 5% nominal wage rise will also cause a rise in the home price level and in the real exchange rate. It will also lead to a reduction in employment, returns on capital, and investment. A 10% devaluation is found to have effects similar to the 5% nominal wage rise.

By adopting the mechanism of nominal exchange rates in a single country model, Yang et al. (2012) added nominal exchange rates in the GTAP model and simulated the ex-ante, short-term impacts of an RMB appreciation on the world economy. The paper claimed that, as RMB appreciates, the Chinese economy will be affected negatively, with lower real Gross Domestic Product (GDP), lower employment rates, and a decline in the trade surplus. Chinese currency appreciation has a positive impact on the GDP of the major countries and regions, but only by a small margin. With a higher Chinese exchange rate, there is significant improvement in trade balances for other trading partner countries, with the exception of the United States.

Using a recursive dynamic GTAP model, Li and Xu (2011) estimated the effects of China's real exchange rate appreciation in the next decade. Two different scenarios are simulated against the baseline, one is an adjustment of the macro-structural imbalance by decreasing the gross national saving rate in China and the other is an adjustment of the micro-structural imbalance by increasing the real wage rate of Chinese labor. The paper concluded that, compared to the real appreciation created by increasing the wage rate, the decrease in the gross national saving rate will help to rebalance China's trade account and improve the Chinese terms of trade in the next decade. In the short run, however, the imbalance is mainly embodied in the trade structure, especially in the bilateral trade of high-technology products between China and USA.

In contrast to previous studies, this paper proposes a multiple currency framework to model the impact of exchange rates. To achieve this end, Section 2 analyzes the problems and shortcomings in previous modeling of exchange rates and then illustrates the new approach of this study. Section 3 provides an implementation of the model — to simulate the impact of a 10% appreciation of RMB. In Section 4, the simulation results at both microeconomic level and sectoral level are discussed. Section 5 concludes the paper.

2. The multiple currency approach

The base model used in this paper is the GTAP model, which has no exchange rate variable in the current version. There are two attempts to add exchange rates in the GTAP model, but these approaches have considerable limitations and even serious problems.

Yang et al. (2012) adopted the treatment of nominal exchange rates in a single country model and applied it to the GTAP model. They added a nominal exchange rate for each region and adjusted the prices of different types of goods. The nominal exchange rate is added to export prices for foreigners and is deducted from import prices for domestic users. The nominal exchange rate is also added to the equations of global transportation as well as the prices of world investment goods and savings. The shortcomings of this approach are evident. First, the exchange rate in this approach does not fit the definition of an exchange rate: the relative price of two currencies. In other words, in the real world, the exchange rate depends on at least two regions, not just one region. For this approach to be valid, the situation in other countries must be unchanged. This means a severe constraint is imposed on a global model.

Secondly, there is only one exchange rate for a region in this approach, so a change in a region's exchange rate means a change of its exchange rate to all other regions (the rest of the world). When we allow a country to change its exchange rate, this approach requires that the degree of change must be the same for all other countries.

Thirdly, one can change the exchange rate for only one country in one simulation. If two countries change exchange rates at the same time (imposing dual shocks), the two shocks contradict with each other because of the bilateral nature of the exchange rate. Consider a dual shock of 10% appreciation for currencies of both country A and country B. A 10% appreciation for country A implies, with respect to country A, a 10% depreciation of currencies of all other countries including country B. This directly conflicts with the second shock a 10% appreciation of the currency for country B.

Fourthly, the changes to the GTAP equations made by this study will lead to violation of homogeneity conditions because of the change in international transportation prices when exchange rates change. The study added the exchange rate term to three GTAP equations regarding the prices of exports, imports and transportation services, as shown as follows (equations are in linear or percentage change form).

$$pfob(i,r,s) = pm(i,r) - tx(i,r) - txs(i,r,s) + nex(r); \quad (1)$$

$$pms(i,r,s) = tm(i,s) + tms(i,r,s) + pcif(i,r,s) - nex(s); \quad (2)$$

$$pt(m) = \sum VTSUPPSHR(m,r) * [pm(m,r) + nex(r)]; \quad (3)$$

where *pfob* is the free-on-border trade price, *pm* is the market price of exporting country, *tx* and *txs* are the different types of export subsidies, *nex* is exchange rate, *pms* is the market price of importing country, *tm* and *tms* are different types of import tariff, *pcif* is the cost-insurance-freight-included trade price, *pt* is the aggregated transportation price, and *VTSUPPSHR* is the regional contribution of international transportation services. '*i*' refers to the types of commodity, '*r*' refers to the exporting country, '*s*' refers to the importing country, and '*m*' refers to types of transportation margin.

Based on Eqs. (1) and (2), the homogeneity condition is satisfied on the surface: *pfob* and *pms* will increase or decrease at the same rate as that of *nex*. However, the *pcif* is determined by both *pfob* and *pt*, shown by two other equations in GTAP:

$$pcif(i,r,s) = FORSHR(i,r,s) * pfob(i,r,s) + TRNSHR(i,r,s) * ptrans(i,r,s); \quad (4)$$

$$ptrans(i,r,s) = \sum VTFSD\_MSH(m,i,r,s) * pt(m,i,r,s); \quad (5)$$

where *FORSHR* is the weight of *pfob* in *pcif*, *ptrans* is the cost of transport commodity *i* form country *r* to country *s*, *TRNSHR* is the weight of *ptrans* in *pcif*, and *VTFSD_MSH* is the weight of *pt* in *ptrans*.

From Eqs. (3) and (5) it is clear that the degree of change in *ptrans* is different from that of *nex* because *nex* only contributes partially to *pt* and thus partially to *ptrans* thanks to the weighted average process. Eq. (1) indicates that *pfob* changes in line with *nex* (assuming no change in *tx*, *txs*). Because the degrees of change in *pfob* and in *ptrans* are different, Eq. (4) necessitates different degrees of changes in *pfob* and in *pcif*. Eq. (2) further gives a different degree of change in *pms*. This means the homogeneity condition is violated in a linear model.

Finally, the price aggregation in the model is not completed. The change in exchange rates, even in one country, will affect all aggregated prices and nominal values. However, this study taken into account the impact of exchange rate changes only for the aggregated investment price and for the aggregated saving price. Consequently, all other nominal aggregations in the model are incorrect.

The approach of Tyers and Yang (2000) also adds a single nominal exchange rate for each region, but they set the exchange rate of the US